Research Bulletin 868 October 1960

THE EFFECT OF SOIL MANAGEMENT SYSTEM AND DIFFERENTIAL NITROGEN FERTILIZATION ON YIELD AND ON THE QUALITY OF . . .

CONCORD GRAPE JUICE

●

J. M. BEATTIE – M. P. BALDAUF

●

OHIO AGRICULTURAL EXPERIMENT STATION
Wooster, Ohio

THE EFFECT OF SOIL MANAGEMENT SYSTEM AND DIFFERENTIAL NITROGEN FERTILIZATION ON YIELD AND ON THE QUALITY OF CONCORD GRAPE JUICE

J. M. BEATTIE and M. P. BALDAUF[1]

INTRODUCTION

Only recently have the commercial processors of grape juice in the northeastern United States recognized the full importance of quality of the raw product. Sugar content has long been a consideration in determining harvest dates and traditionally it has been recognized that certain years were vintage years in so far as grape quality was concerned. For the most part, however, the evaluation of grape quality has remained subjective with such factors as color of the fruit, taste, and ease of separation of the berries from the cluster being the determining factors. Under these circumstances the grower was inclined to produce the largest possible tonnages per acre because his income from the crop was determined by the number of tons of grapes produced.

It was under these conditions that the soil management and fertilizer experiments were begun in 1945 at the Ohio Agricultural Experiment Station. The primary objective of this work was to determine those practices which would result in highest yields of grapes. Before the work had progressed very far, it became apparent that certain nitrogen fertilizer treatments and the mulch system of soil management resulted in significant increases in yield. It was also recognized that as yields were improved by nitrogen fertilization and the use of a mulch system, the soluble solids content of the fruit was lowered and maturity appeared to be delayed (4).

This presented a new problem. Just how far was it feasible to go in terms of increasing per acre yields without lowering the quality of the fruit below the point of acceptability? It was with this question in mind that in 1955 a detailed evaluation of the effect of various nitrogen fertilizer and soil management treatments on the quality of the raw and

[1]Formerly, Assistant Professor, Department of Horticulture, Ohio Agricultural Experiment Station, now member of Research Staff, The Quaker Oats Co., Berrington, Illinois.

finished product was initiated. The present report deals with these findings and attempts to correlate and associate production practices with fruit quality and with the quality of the processed product.

METHODS

The Experimental Vineyard.

The vineyard was located at the Ohio Agricultural Experiment Station on a level tract of Wooster silt loam soil. Plants were set in the spring of 1944 in nine foot rows with nine foot spacing in the rows. The permanent trellis was in place by the beginning of the second growing season. It consisted of a two-wire trellis with the top wire at 5½ feet above ground level. The vines were trained to the four-cane Kniffin system. By the spring of 1948 it became apparent that the vigor of the vines was such that additional trellis was required. At that time the trellis was raised to permit the use of three wires with the top wire at 6 feet above ground level and vines were trained to either the four or six-cane Kniffin system depending on vine vigor. Beginning in 1956 the training system has gradually been modified to the umbrella Kniffin system.

Differential treatments were begun in 1945. Two rows, each consisting of 29 vines of the Concord variety, were utilized in the test. These rows were separated by a guard row. One row was mulched with wheat straw at the rate of 10 tons per acre. The entire aisle area on either side of this row was covered with straw. The mulch was replenished annually to maintain a layer of straw of from 10-12 inches in depth. From 1945 to 1957 the equivalent of about 70 tons per acre of straw has been applied. The second row was maintained for the same period under the cultivation plus cover crop system of soil management. Rye was sown in late August of each year and disced down in the early spring. Cultivation for the remainder of the season was accomplished by light discing of the row middles and by hand hoeing under the trellis.

Each of the two rows was further treated with different rates of application of nitrogen fertilizer. For this purpose each row was divided into six four-vine subplots separated by a single buffer vine. Three treatments were employed. These consisted of annual 0, 40, and 80 pound per acre applications of actual nitrogen. Thus, each treatment occurred twice under each system of soil management. The fertilizer applications were made in early April each year to an area 2½-3 feet wide under the trellis. In 1955 and 1956 an application of 1 pound per vine of potassium sulfate was made to all vines in the cultivated row.

From the time the vineyard was established through 1951 all vines were pruned in a manner similar to growth practice with respect to the number of buds left per vine. Since 1952 all vines were pruned so as to leave 30 buds for the first pound of one-year prunings and 10 additional buds for each additional pound of one-year prunings. Detailed records were maintained as to the weights of prunings removed and number of buds left in pruning.

Leaf Petiole Samples.

During each of the three years from 1955 through 1957, composite samples of the leaf petioles were taken during the first week of July for chemical analysis. Twelve leaves from each of four vines within a subplot were taken to make the composite 48 leaf sample. The first mature leaf from the tip of a fruiting shoot was used. The leaf blades were separated from the petioles and discarded. A total of twelve such samples were taken each year representing the duplicate plots of two soil management systems and three levels of nitrogen fertilizer application. These samples were dried at 75° C., ground in a standard Wiley mill and stored in tightly capped glass bottles prior to analysis.

Total nitrogen was determined using the official Kjeldahl Gunning method (3). In 1955, total phosphorus was determined by the semimicro method of Peech (8) and total calcium, magnesium, and potassium were determined flame photometrically using the quartz spectrophotometer with flame attachment and photomultiplier. In 1956 and 1957 phosphorus, calcium, magnesium, and potassium were determined spectrographically using the B & L 1.5 meter replica grating spectrograph. All results are expressed on the dry weight basis.

Yield Records.

Harvest records were taken each year since fruiting began by removing and counting the number of clusters produced per vine and obtaining the weight of fruit produced per vine. Since the detailed measurements on fruit quality reported herein cover the years 1955 through 1957, the yield data for those years only will be presented in detail. Harvest dates were as follows: September 19, 1955; September 25, 1956; September 23, 1957.

Fruit Samples.

Each season at harvest time a two bushel composite sample from all vines of each treatment was obtained for the quality evaluations. Each composite sample represented fruit from the eight vines receiving a particular treatment. The fruit samples were stored at 34° F. for several days until processing could be accomplished.

Freshly Expressed Juice of the Raw Grape.

The juice sample for the determination of fresh fruit quality was secured from grape clusters picked from each of the duplicate four vine plots for each treatment variable. A random subsample of about one hundred berries was taken for cold pressing in a small hydraulic press. The sample was wrapped in fine mesh cloth and pressed with a gauge pressure of 4,000 pounds per square inch. The pressure was approached slowly and held for a period of 20 seconds. This cold pressed juice was used in all of the analytical methods except tannin for the data on the fresh grape.

The juice extraction of the raw grapes for the 1955 season was by use of a small hand lever juice extractor. The pressure that could be applied was rather low and consequently the samples were not as completely expressed as in 1956 and 1957. The extracted juice of the fresh raw grapes will, hereafter, be known as raw grape juice.

Grape Juice Manufacture.

The grapes were washed with a water spray, stemmed by a small mechanical stemmer, and crushed in a hand operated grape crusher. The crushed grapes were heated in a steam kettle to 145° F., placed into press cloths and the juice pressed out in a hydraulic press. The heating was done to extract color, body and flavor from the skins and increase the yield of juice. The extracted juice was pasteurized at 185° F., filled into large glass containers while hot, and sealed. These containers of juice were then cooled and held at 34° F. for two to three months to allow thorough tartrate deposition. The juice was then decanted or siphoned off the tartrate deposition, filtered, heated to 180° F., filled into bottles, sealed, and cooled. The juice was stored at room temperature for approximately six months before being analyzed and offered to the taste panel. This grape juice will, hereafter, be called finished grape juice.

Analytical Methods.

(A) Total Soluble Solids.

The raw grape juice was used directly in an Abbe refractometer to determine the percent soluble solids of the grapes.

The finished grape juice was also used directly in the Abbe refractometer to determine the percent soluble solids of the grape juice.

(B) Total Acids.

Total acids were determined on samples of both the raw and finished grape juice. A 10 ml. sample was diluted with 100 ml. distilled water and titrated with approximately 0.1 normal sodium hydroxide to an end point of pH 8.3 as measured by a Beckman pH meter. The total acids were calculated and expressed as tartaric acid.

(C) Acidity.

The acidity or pH was determined with the Beckman pH meter, using a glass electrode. The raw juice was used for the fresh fruit determination while the undiluted finished juice was used for the grape juice determination.

(D) Tannin Content.

The raw grape sample for the determination of tannin was secured by cutting the grapes in half, removing the seeds, and using only half of the grape in order to get a more representative sample. Fifty grams of the deseeded grapes were blended with 300 ml. of 70 percent ethyl alcohol in a Waring blender for three minutes. This material was centrifuged and one or two ml. of this solution used in the method of Rosenblatt and Peluso (10), which is a photometric method involving the use of the Folin-Denis reagent.

The finished grape juice sample was prepared by taking 2 ml. juice and diluting it with 20 ml. distilled water. Two ml. of this diluted juice was used in the Rosenblatt and Peluso method.

Organoleptic Evaluation.

The triangular test or odd sample method was used to determine if there were any differences between the lots of juice produced from the grapes grown under the various soil management practices. In this test the taster was served, at the same time, three samples identified only by random letters. He was aware that two of the samples were identical and the other was different and was asked to pick out the odd or different sample. He was also asked to tell which of the two kinds of juice he preferred. From the number of correct identifications of the odd sample, it was calculated whether or not there was a significant difference between the two lots of juice. Roessler, Warren and Guymon (9) have discussed significance and its calculation in triangular taste tests.

Since there was a difference in color of the juices, the organoleptic testing was done in a darkened room of very low light intensity. The judging was solely on the basis of flavor.

EXPERIMENTAL RESULTS

Yields and Harvest Data.

A detailed record of the yields obtained under the differential soil management and nitrogen treatments from 1947 through 1953 was made in a previous report (4). In order to acquaint the reader with the yield response in the years prior to 1955, a summary of yields under mulch and cultivation soil management systems and with different rates of nitrogen fertilizer application is given in Table 1. These data clearly show a significant increase in yield from those vines which were maintained under the mulch system. Yield differences resulting from differential nitrogen treatments were not significant because of the interaction between soil management system and nitrogen fertilization. Only when each soil management system was considered independently were the yield differences due to nitrogen apparent. Under the cultivation system, the application of 80 pounds of actual nitrogen per acre per year resulted in a significant increase in yield over the 0 and 40 pounds nitrogen treatments. With the mulch system, the application of nitrogen fertilizer did not result in any change in yield as compared with no nitrogen.

Yield data for the period 1955 through 1957 are presented in Figure 1. The yield response to management practices in 1955 was similar to that obtained previously. Mulched vines outyielded cultivated vines. The interaction between soil management system and nitrogen application was also evident with increased yields as the nitrogen application increased under cultivation and decreased yields with increasing nitrogen application under the mulch system. In 1956 and

TABLE 1.—The effect of soil management system and differential nitrogen fertilization on the average yield of Concord grapes from 1947 through 1954.

Nitrogen treatment	Soil Management System		Nitrogen treatment Means
	Cultivation	Mulch	
	lbs. per vine	lbs. per vine	
No Nitrogen	10.2	17.3	14.0
40 lbs. N/Acre/yr.	10.7	19.1	14.9
80 lbs. N/Acre/yr.	15.1	16.8	15.9
Soil Management Means	12.0	17.9	

L.S.D. Soil Management Means	5%	1.78
	1%	2.47
L.S.D. Nitrogen Treatment Means	5%	N.S.
	1%	N.S.
L.S.D. Soil Management $\times$ Nitrogen Means	5%	3.08
	1%	N.S.

1957 a complete reversal in yield response to that which existed previously was found between soil management systems. In those years the cultivated vines outyielded mulched vines. This trend was apparent in 1956, but the differences were not statistically significant. By 1957, however, the cultivated vines outyielded the mulched vines to a highly significant degree (Figure 1).

The number of clusters produced per vine was influenced by both nitrogen application rate and soil management system. These data are presented in Figure 2. Under the cultivation system the average number of clusters per vine increased as nitrogen application increased. With mulch cluster number increased as the first increment of nitrogen was supplied but decreased as the nitrogen application was further raised to 80 pounds per acre per year, except in 1956 when there was essentially no difference between nitrogen treatments. Under the mulch

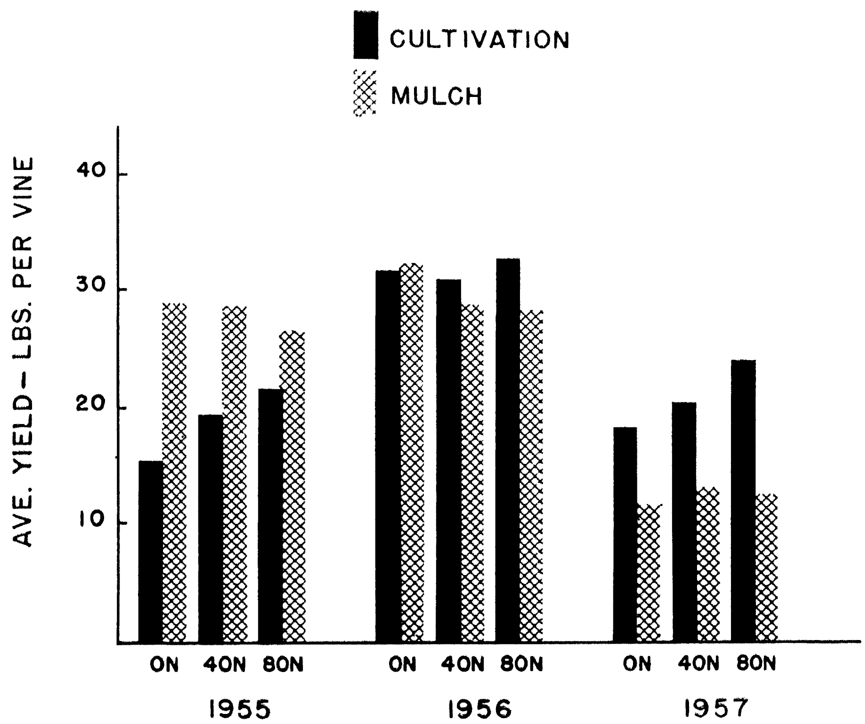

Fig. 1.—The effect of soil management system and differential nitrogen fertilization on the average yield per vine of Concord grapes from 1955 through 1957.

system many more clusters per vine were produced in 1955 and slightly more in 1956 than under cultivation. In 1957, however, the cultivated vines produced more clusters per vine than did mulched vines.

The relationship between cluster number and total yield is reflected by the average weight of clusters (Figure 3). The cultivated vines consistently produced larger clusters than did mulched vines. Moreover, under the mulch system the application of either 40 or 80 pounds per acre of nitrogen failed to increase cluster size over no nitrogen while under cultivation the 40 pound nitrogen rate resulted in the largest sized clusters in 1955 and 1957.

Still another criterion of the productive capacity of vines under the two soil management systems is the relationship between the number of buds left at pruning time and the amount of fruit produced on these

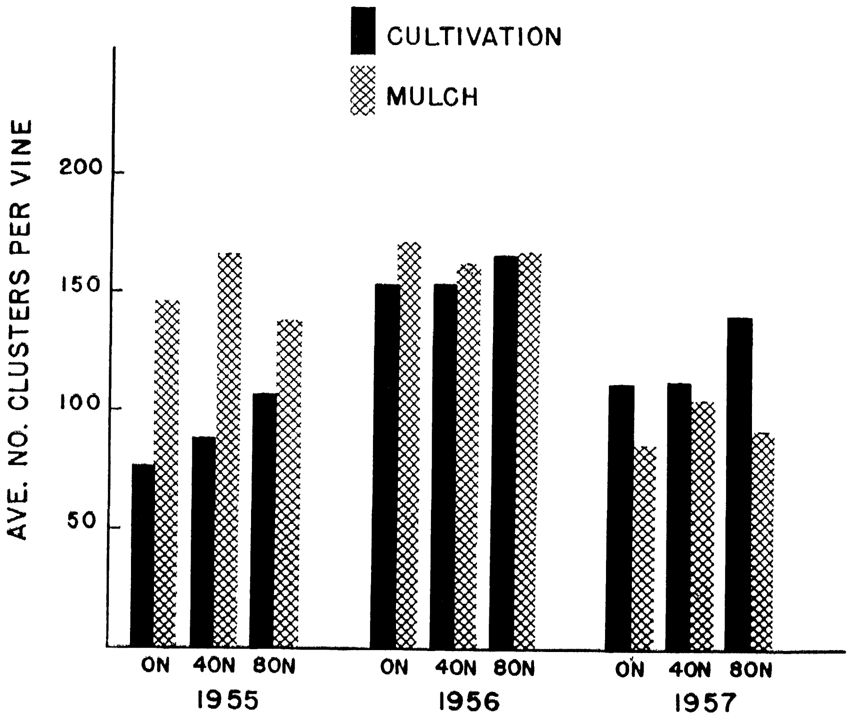

Fig. 2.—The effect of soil management system and differential nitrogen fertilization on the average number of clusters per vine on Concord grapes, 1955 through 1957.

vines. This may be evaluated by dividing the number of buds left during pruning into the total weight of fruit produced. The resulting value is the average weight of fruit produced per bud (Table 2) and is referred to herein as "fruitfulness per bud." These data show that fruitfulness per bud was fairly high under the mulch treatment in 1955 when the yield of the mulched vines was also high but was markedly reduced under mulch in 1956 and very greatly reduced in 1957. Fruitfulness per bud was consistently greater under cultivation than under mulch.

One of the benefits from the mulch system of soil management was thought to be an increased supply and/or availability of certain essential plant nutrients. In as much as this might account in part for yield differences and differences in fruit quality, leaf petiole analysis data for 1955 through 1957 are presented in Table 3. These data show that nitrogen, phosphorus, and potassium contents of the leaf petioles were

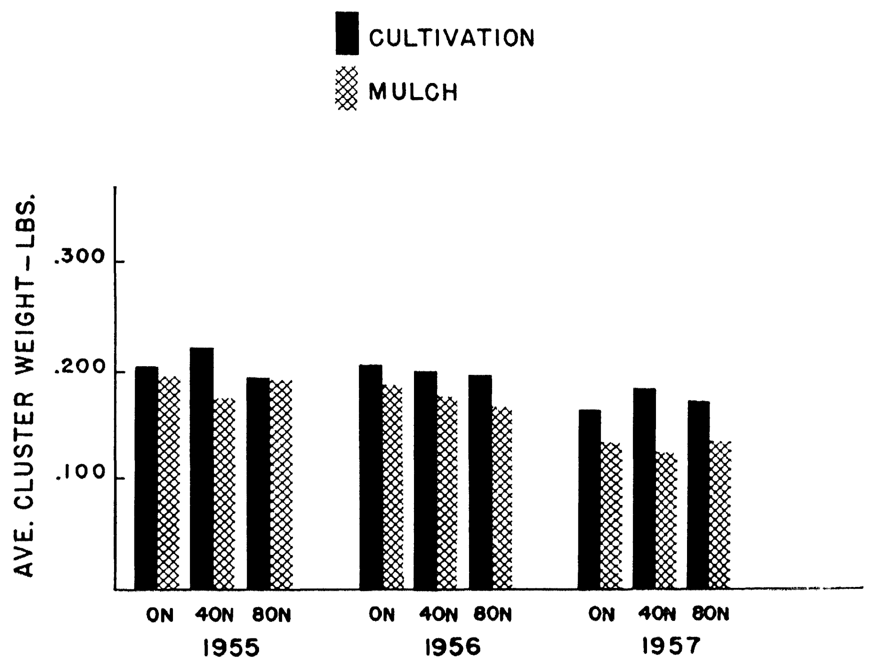

Fig. 3.—The effect of soil management system and differential nitrogen fertilization on the average weight per cluster of Concord grapes from 1955 through 1957.

TABLE 2.—The effect of soil management system and differential nitrogen fertilization on the pounds of fruit produced per bud by Concord grapes from 1955 through 1957.

Nitrogen Treatment	Soil Management System: Cultivation 1955	1956	1957	Mulch 1955	1956	1957
	Pounds fruit per bud			Pounds fruit per bud		
No Nitrogen	0.65	0.64	0.44	0.63	0.41	0.16
40 lbs. N/Acre/yr.	0.78	0.61	0.44	0.51	0.35	0.17
80 lbs. N/Acre/yr.	0.61	0.57	0.45	0.50	0.35	0.17

higher under the mulch system of management while calcium and magnesium were higher under the cultivation system of management. The potassium levels of the mulched vines in 1955 and of both mulched and cultivated vines in 1956 were too high to permit quantitative determination by the analytical methods employed. They are given in Table 3 as higher than 3.00 percent in 1955 and higher than 3.50 percent in 1956. The following year the analytical method was modified to permit quantitative determination beyond the levels found in the leaf petioles.

Considering the mean values for all three years (Table 3) it should be noted that nitrogen and magnesium under both soil management systems and phosphorus and potassium under the mulch system increased as the rate of nitrogen application increased.

Chemical Analysis of Fruit Juice.

The quality of both raw and finished grape juice from the various treatments was evaluated by physical and chemical measurements the results of which are summarized in Table 4.

In both raw and finished juice the pH was higher and consequently the hydrogen ion concentration was lower in the case of mulch than under cultivation (Table 4). Under neither of the soil management systems did there appear to be an appreciable influence of differential nitrogen treatment upon pH (Table 4) of the raw or finished juice. The year to year variation in pH of both raw and finished juice was greater than that resulting from any imposed treatment. In 1956 when maturation of the crop was halted by frost the pH of all lots of juice was considerably lower than in either 1955 or 1957 when normal maturity was reached.

TABLE 3.—The effect of soil management system and differential nitrogen fertilization on the July leaf petiole composition of Concord grape vines from 1955 through 1957. All data are expressed as percent of the dry weight.

Year	Cultivation			Mulch		
	No N	40 lbs. N	80 lbs. N	No N	40 lbs. N	80 lbs. N
			Percent Nitrogen			
1955	0.85	0.94	0.95	1.25	1.31	1.78
1956	1.15	1.25	1.25	1.54	1.47	1.61
1957	1.06	1.34	1.22	1.62	1.70	1.51
Mean	1.02	1.18	1.14	1.47	1.49	1.63
			Percent Phosphorus			
1955	0.156	0.151	0.097	0.182	0.234	0.248
1956	0.157	0.139	0.177	0.280	0.227	0.394
1957	0.173	0.215	0.162	0.324	0.405	0.311
Mean	0.162	0.168	0.145	0.262	0.289	0.318
			Percent Potassium			
1955	1.25	1.46	0.91	>3.00	>3.00	>3.00
1956	>3.50	>3.50	>3.50	>3.50	>3.50	>3.50
1957	3.33	3.20	2.70	4.99	5.45	6.05
Mean	----	----	----	----	----	----
			Percent Calcium			
1955	1.27	1.16	0.92	1.04	1.03	0.95
1956	0.73	0.36	0.75	0.34	0.34	0.20
1957	0.96	0.78	0.81	0.79	0.51	0.79
Mean	0.99	0.77	0.83	0.72	0.63	0.65
			Percent Magnesium			
1955	0.418	0.431	0.400	0.170	0.196	0.212
1956	----	----	----	----	----	----
1957	0.241	0.234	0.280	0.146	0.115	0.143
Mean	0.329	0.333	0.340	0.158	0.156	0.178

TABLE 4.—The chemical composition of the raw and finished Concord grape juice made from grapes grown under cultivation and mulch soil management systems with 0, 40, and 80 pound per acre applications of nitrogen.

			RAW GRAPE JUICE				
Soil Management System	Pounds Nitrogen per Acre	Year	pH	Acidity as Tartaric	Soluble Solids	Soluble Solids Acid Ratio	Tannin
				%	%		Mg. %
		1955	3.30	0.57	16.6	29.1	----
Cultivation	0	1956	2.92	1.31	12.3	9.4	262
		1957	3.10	0.69	16.4	23.8	294
		1955	3.23	0.66	15.5	23.5	----
Cultivation	40	1956	2.98	1.29	11.9	9.2	245
		1957	3.10	0.75	15.9	21.2	306
		1955	3.14	0.54	16.0	29.6	----
Cultivation	80	1956	2.95	1.25	12.8	10.2	264
		1957	3.05	0.78	16.3	19.6	293
		1955	3.45	0.67	14.6	21.8	----
Mulch	0	1956	3.11	1.55	11.3	7.3	172
		1957	3.40	0.85	15.9	18.7	299
		1955	----	----	----	----	----
Mulch	40	1956	3.15	1.52	11.1	7.3	194
		1957	3.40	0.88	15.0	17.1	313
		1955	3.40	0.63	14.2	22.5	----
Mulch	80	1956	3.10	1.66	10.6	6.4	184
		1957	3.40	0.78	16.0	20.5	316
			FINISHED GRAPE JUICE				
Soil Management System	Pounds Nitrogen per Acre	Year	pH	Acidity as Tartaric	Soluble Solids	Soluble Solids Acid Ratio	Tannin
				%	%		Mg. %
		1955	3.28	0.77	15.8	20.5	187
Cultivation	0	1956	3.10	1.30	11.2	8.6	191
		1957	3.25	0.91	15.9	17.5	257
		1955	3.22	0.83	16.0	19.3	190
Cultivation	40	1956	3.11	1.25	11.5	9.2	151
		1957	3.30	0.96	16.8	17.5	292
		1955	3.25	0.72	15.0	20.8	195
Cultivation	80	1956	3.00	1.24	12.0	9.7	202
		1957	3.30	0.94	16.0	16.9	270
		1955	3.52	0.87	12.2	14.0	157
Mulch	0	1956	3.20	1.25	10.0	8.0	116
		1957	3.60	0.93	14.8	15.9	213
		1955	3.55	0.80	12.2	15.3	150
Mulch	40	1956	3.32	1.38	10.2	7.4	129
		1957	3.65	0.93	14.9	16.0	233
		1955	3.50	0.78	12.0	15.4	155
Mulch	80	1956	3.20	1.41	10.0	7.1	148
		1957	3.60	0.91	14.9	16.4	195

The total acid content of raw grape juice from mulched vines was higher than from comparable cultivated vines (Table 4). This was not the case, however, after the juice had been processed into the finished product at which time both lots had about the same total acid content. Differential nitrogen treatment within each soil management system did not materially alter the acid content of either raw or finished juice. As with pH, much larger differences in total acid content occurred between seasons than as the result of either soil management or nitrogen treatments.

The mulch system resulted in a general lowering of the soluble solids content of both raw and finished grape juice (Table 4). Comparing similar nitrogen treatments the reduction in percent soluble solids in raw grape juice as a result of mulch ranged from 0.3 to 2.2 while with finished grape juice this range extended from 1.1 to 3.8. Thus, the reduced soluble solids content under the mulch system of production was in some way amplified in the processing of the juice and its subsequent storage. The soluble solids content of raw or finished juices was not influenced by differential nitrogen treatment. The low soluble solids contents reported for 1956 clearly show the effect of early fall frost on the maturation of the crop in that year (Table 4).

The soluble solids-acids ratio of the raw and finished juices of mulched vines was consistently lower than from comparable cultivated vines. These differences were greatest in the case of raw juice and less following processing and the storage period. There were no consistent effects of differential nitrogen treatment upon the soluble solids-acids ratio of either raw or finished juices. Generally speaking, the data show (Table 4) that the ratio of soluble solids to acids decreased from the value obtained in the raw juice to a lower level in the finished juice. The seasonal difference which was apparent in both soluble solids and acids data was again clearly shown in the mathematical ratio relating these two indices of quality.

Tannin was not determined in 1955 on the raw juice samples. The tannin content of raw juice in 1956 and in the finished juice for all three years showed that juice from mulched vines contained lower tannins than that from similarly treated cultivated vines. In 1957, however, the tannin content of raw juice from the three nitrogen treatments under cultivation was slightly less than from corresponding mulched vines. The levels of nitrogen fertilizer application used did not appear to have an effect on the tannin content of either raw or finished juices.

Organoleptic Tests.

The results of the organoleptic tests are presented for finished grape juice in Table 5. Three series of comparisons were made in the tests. The first comparison was between juice from mulched vines which received different rates of nitrogen application. In no case could the members of the taste panel detect a difference between the different nitrogen treatments under the mulch system of soil management (Table 5). The second comparison was between juices from cultivated vines which received different nitrogen treatments. In this case in only one comparison during the three years were the members of the panel able to detect a difference. This instance involved the comparison of juice from no nitrogen and 40 pound per acre per year nitrogen treatment and the preference was for juice from the no nitrogen cultivation plots (Table 5). The third series involved a comparison of juice from cultivated and mulched vines which received the same nitrogen treatment. In every instance the panel members could detect a difference. The preference was for the juice made from grapes grown under cultivation during 1955 and 1956 and for juice from grapes grown under mulch in 1957. The differences in 1955 were significant at the 1 percent level and for 1956 and 1957 at the 5 percent level. Statistical treatment of the data for the three years' period showed that there was a distinct preference for juice from the cultivated vines and that odds favoring this preference were very highly significant.

Samples of grape juice from mulched and cultivated vines were again submitted to the taste panel after the soluble solids-acids ratio of the juice from mulched vines was made equal to that of juice from cultivated vines at each level of nitrogen treatment. This adjustment of the soluble solids-acids ratios was accomplished by the addition of sugar. The results of the evaluation of these adjusted samples are presented in Table 6. In 1955 and again in 1956, members of the taste panel were unable to distinguish between juice samples from the two soil management treatments after the soluble solids acids ratios were equalized by adding sugar to the juice samples from mulched vines. In 1957, however, panel members expressed a definite preference for the juice from mulched vines at the no nitrogen and 40 pound nitrogen treatments. This indicated that some factor or factors other than soluble solids-acids ratio was responsible for the preference of these juices during that particular season.

TABLE 5.—Triangular taste testing data of finished Concord grape juice made from grapes grown under cultivation and mulch soil management systems with 0, 40, and 80 pound per acre applications of nitrogen.

Treatment Comparison	1955			
	Total Number Judgments	Total Number Correct Judgments	Significance	Preference of Correct Judgments
0N Mulch 40N Mulch	8	5	--	--
40N Mulch 80N Mulch	8	3	--	--
0N Mulch 80N Mulch	8	5	--	--
0N Cultivation 40N Cultivation	8	4	--	--
40N Cultivation 80N Cultivation	8	0	--	--
0N Cultivation 80N Cultivation	8	4	--	--
0N Cultivation 0N Mulch	10	10	‡	10 0
40N Cultivation 40N Mulch	10	9	‡	9 0
80N Cultivation 80N Mulch	10	8	†	8 0

Treatment Comparison	1956			
	Total Number Judgments	Total Number Correct Judgments	Significance	Preference of Correct Judgments
0N Mulch 40N Mulch	9	4	--	--
40N Mulch 80N Mulch	9	4	--	--
0N Mulch 80N Mulch	9	4	--	--
0N Cultivation 40N Cultivation	9	6	*	--
40N Cultivation 80N Cultivation	9	1	--	--
0N Cultivation 80N Cultivation	9	2	--	--
0N Cultivation 0N Mulch	9	6	*	5 1
40N Cultivation 40N Mulch	9	6	*	5 1
80N Cultivation 80N Mulch	9	6	*	5 1

TABLE 5.—Triangular taste testing data of finished Concord grape juice made from grapes grown under cultivation and mulch soil management systems with 0, 40, and 80 pound per acre applications of nitrogen—Continued.

Treatment Comparison	1957			
	Total Number Judgments	Total Number Correct Judgments	Significance	Preference of Correct Judgments
0N Mulch 40N Mulch	9	4	--	--
40N Mulch 80N Mulch	9	2	--	--
0N Mulch 80N Mulch	9	3	--	--
0N Cultivation 40N Cultivation	10	2	--	--
40N Cultivation 80N Cultivation	10	4	--	--
0N Cultivation 80N Cultivation	10	4	--	--
0N Cultivation 0N Mulch	26	14	*	5 9
40N Cultivation 40N Mulch	26	14	*	6 8
80N Cultivation 80N Mulch	26	15	*	10 5

Treatment Comparison	3 Year Total			
	Total Number Judgments	Total Number Correct Judgments	Significance	Preference of Correct Judgments
0N Mulch 40N Mulch	26	13	--	--
40N Mulch 80N Mulch	26	9	--	--
0N Mulch 80N Mulch	26	12	--	--
0N Cultivation 40N Cultivation	27	12	--	--
40N Cultivation 80N Cultivation	27	5	--	--
0N Cultivation 80N Cultivation	27	10	--	--
0N Cultivation 0N Mulch	45	30	‡	20 10
40N Cultivation 40N Mulch	45	29	‡	20 9
80N Cultivation 80N Mulch	45	29	‡	23 6

* = P of .05.
† = P of .01.
‡ = P of .001.

TABLE 6.—Triangular taste testing data of finished Concord grape Juice made from grapes grown under cultivation and mulch soil management systems with 0, 40, and 80 pound per acre applications of nitrogen. The soluble solids-acid ratios of each comparison were equalized by the addition of sugar.

Treatment Comparisons with Equal Soluble Solids-Acid Ratios	Total Number Judgments	Total Number Correct Judgments	Significance	Preference of Correct Judgments
1955				
0N Cultivation 0N Mulch	8	4	--	--
40N Cultivation 40N Mulch	9	5	--	--
80N Cultivation 80N Mulch	8	4	--	--
1956				
0N Cultivation 0N Mulch	10	0	--	--
40N Cultivation 40N Mulch	10	4	--	--
80N Cultivation 80N Mulch	10	5	--	--
1957				
0N Cultivation 0N Mulch	12	8	*	0 8
40N Cultivation 40N Mulch	12	10	‡	3 7
80N Cultivtiaon 80N Mulch	12	9	†	5 4

* = P of .05.
† = P of .01.
‡ = P of .001.

DISCUSSION

Yields.

Yield data obtained prior to the initiation of the detailed fruit quality study showed clearly that Concord vines maintained under a permanent straw mulch significantly outyielded comparable vines under a cultivation plus cover crop system of management (Table 1). These mulched vines have also consistently shown greater vegetative vigor as measured by weight of one-year old wood produced. On the basis of these earlier results it was assumed that higher yields under mulch would continue throughout the course of the quality evaluation phase of the work begun in 1955. This did not prove to be the case for although in 1955 the mulched vines outyielded cultivated vines, in 1956 the average yield per vine from the two soil management systems was nearly the same, and in 1957 cultivated vines significantly outyielded mulched vines. In an earlier report summarizing the production record of this vineyard from 1947 through 1953 (4) the increased yields under the mulch system were attributed to two major factors. These were first, an improved moisture situation beneath the mulch and second, increased levels of certain essential plant nutrients within the leaf petioles notably nitrogen and potassium.

In order to explain the shift in production behavior of the two soil management systems, a reappraisal of the leaf petiole composition data presented in Table 3 is necessary. With respect to nitrogen this has been accomplished by plotting yield per vine as a function of the nitrogen content of leaf petioles for the years 1955 through 1957 (Figure 4). In considering these nitrogen yield relationships it should be pointed out that at no time during the years 1955 through 1957 did the petiole concentration of nitrogen from the cultivated vines exceed 1.34 percent of the dry weight. Under mulch, however, vines which received 80 pounds per acre of nitrogen in 1955 and vines of all nitrogen treatments in 1956 and 1957 produced leaf petioles with nitrogen contents in excess of 1.34 percent. The nature of these petiole nitrogen-yield relationships (Figure 4) for all three years indicate that within the range of about 0.85 to 1.30 percent nitrogen there is a direct and positive correlation between nitrogen content of the leaf petiole and yield and that when the nitrogen level exceeds 1.30 percent yields show no further improvement with increased nitrogen or may actually be reduced. This occurred whether vines were maintained under the mulch or cultivation system of soil management, for in 1955 the highest yields obtained under mulch when petiole nitrogen was 1.25 and 1.31 percent nitrogen for the 0 and 40 N treatments respectively and no further increase in yield resulted when petiole nitrogen advanced to 1.78 percent under the 80 N treatment (Table 3 and Figure 4). In contrast in both 1956 and 1957 cultivated vines outyielded mulched vines and in no case did the nitrogen content of the petioles exceed 1.34 percent for these cultivated vines while that for mulched vines ranged from 1.47 to 1.70 percent nitrogen. Thus, it appears that the nitrogen status of the vine, not the soil management system as such, was primarily responsible for productive capacity. Furthermore, since there was a variation in nitrogen from year to year within and between the two soil management systems it is suggested that factors other than soil management system were influential in determining the accumulation of nitrogen in the leaf petioles of these Concord grape vines.

The situation with respect to potassium is not as clearly defined. This is due in part to the fact that absolute values for petiole potassium were not available for all three years. As indicated previously, in 1955 the maximum values of 3.00 percent potassium were as high as could be determined with the analytical technique employed and in 1956 the upper limit of the determination was 3.50 percent potassium. Thus, all mulched treatments produced petiole levels in excess of the amount

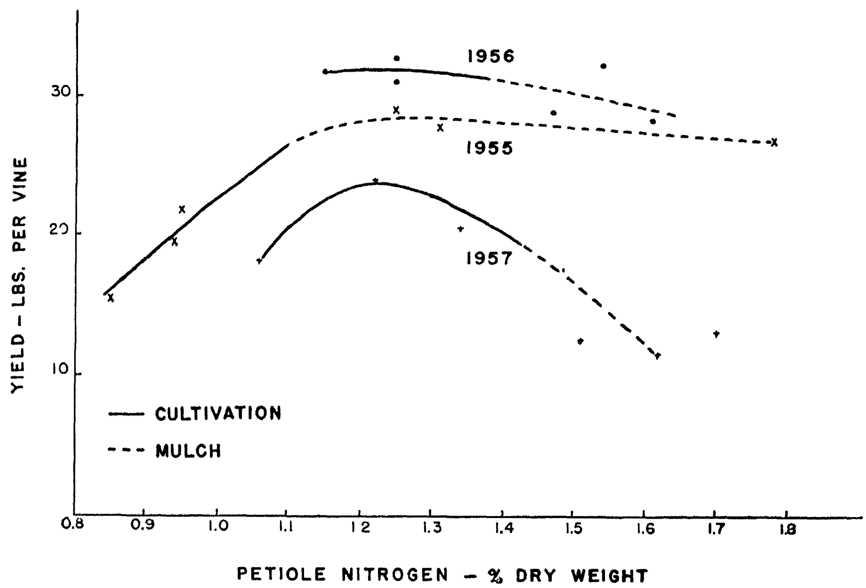

Fig. 4.—The relationship of the early July leaf petiole concentration of total nitrogen to the average yield per vine of Concord grapes grown under the cultivation and mulch systems of soil management.

determinable in 1955 and both cultivated and mulched treatments exceeded this limit in 1956. Despite these limitations of the data, higher levels of potassium were found associated with the mulch system of management as had been indicated in an earlier report (4). In 1954 it had been observed that visual symptoms of potassium deficiency were in evidence during the later part of the growing season in cultivated plots. Consequently, an application of one pound per vine of potassium sulfate was made in the spring of 1955 and again in 1956. This accounts for the greatly increased leaf petiole contents of potassium in cultivated vines in 1956 and 1957. In 1957 when absolute values for petiole potassium are given (Table 3), the familiar inverse relationship between nitrogen and potassium is evident in the case of cultivated vines. Under mulch, however, with much higher concentrations of nitrogen and potassium, the potassium content of the foliage increased in direct relationship with petiole nitrogen. These high potassium levels (4.99 to 6.05 percent) were, therefore, just as closely associated with reduced yields as were the previously mentioned high nitrogen levels of 1.51 to 1.70 percent. Were it not for the high vegetative vigor of these mulched vines which was reflected in weight of one-year old prunings removed and which was more logically a result of excessive nitrogen than of high potassium, it might be assumed that high potassium was as much responsible for reduced yields under the mulch system as was nitrogen itself.

Under both soil management systems the mean magnesium content of the petioles increased as the nitrogen application rate increased, but this was not shown in the data for individual years (Table 3). The higher magnesium values which occurred under cultivation reflected the well established inverse relationship between potassium and magnesium. Foliage levels of calcium and phosphorus were not associated with nitrogen and soil management treatment or with yield except that phosphorus was relatively higher and calcium relatively lower under the mulch system than under cultivation. In view of the larger and more consistent differences which occurred with respect to nitrogen and potassium in relation to soil management system and yield it is believed that the differences found in magnesium, phosphorus and calcium are relatively unimportant in accounting for yield and quality differences under consideration in this report.

Earlier it was suggested that some factor or factors other than soil management and nitrogen treatment appeared to be of primary importance in determining the nitrogen status of the grape vines under treatment. Since improved moisture conditions were suggested (4) earlier as one of the principal benefits of mulch and because actual soil moisture data were not obtained in the present study, a review of rainfall records in relation to soil management system and yield response appeared to be in order. Prior to 1955 there was only one year when the yield of cultivated vines exceeded that of mulched vines. This was in 1950 when the rainfall during the months of the growing season from May through September was 19.89 inches. That year the cultivated vines outproduced mulched vines by an average of 3.8 pounds per vine. During 1955, 1956 and 1957 the total precipitation for the months May through September was 17.26, 25.42, and 26.61 inches, respectively. Thus, during 1950, 1956 and 1957 when cultivated vines equalled or surpassed the mulched vines in total yield the rainfall during the growing season was above the 68 year average. This indicates that somewhere within the range of 17.26 and 19.89 inches of precipitation during the five months of the growing season exists a level of rainfall above which Concord grapes on Wooster silt loam soil are not benefited by the moisture conserving effects of the mulch system of management. Furthermore, in this well drained soil, the higher moisture levels, good aeration, and more uniform soil temperatures under the well decomposed mulch may be responsible for a higher rate of nitrification and the resulting excessive nitrogen concentrations found in the petioles of mulched vines. Such effects would all appear to be aggregated by excessive amounts of rainfall during the growing season.

In view of the foregoing discussion and interpretation of the data, the real cause of reversal in production behavior of mulched and cultivated vines is believed to be a shift in nitrogen status. Mulched vines had always exhibited a higher level of petiole nitrogen than cultivated vines and had in fact nitrogen status very close to the point of nitrogen excess. This region of nitrogen excess, which the present work would suggest is just beyond the range of 1.25-1.35 percent of the dry weight of petioles sampled in early July was reached in the case of mulched vines during growing seasons when rainfall from May to September equalled or exceeded 19.89 inches.

Soluble Solids.

The soluble solids content of the expressed juice of the grape is widely considered as a valid and useful means of evaluating time of maturity and quality. At the present time it is used by commercial processors of grape juice to determine both the acceptability of the growers crop for processing into juice and as an index in establishing the price which is to be paid for the crop. This is best illustrated by a case in point in which a processor has set a level of 15 percent soluble solids as the minimum for acceptability and pays a bonus for soluble solids above this minimum level. In as much as the actual amount of the bonus does not appear to be sufficient to justify severe curtailment of yields per acre in order to obtain highest possible soluble solids content of the fruit, the problem of the grower is to adopt those practices which insure meeting the minimum requirements for solids content while maintaining the highest possible yields. Under these circumstances the influence of soil management and fertilizer treatments upon yield and soluble solids content of the fruit should be of utmost importance to the grower of grapes for processing.

In the present study the soluble solids content of both raw and finished grape juices was less under the mulch system of soil management (Table 4). If the data for the year 1956 are disregarded for the reason that frost prevented the proper maturation of the crop, it is found that the average solids content of cultivated grapes was 16.1 percent while that of mulched grapes was 15.1 percent. In six out of six times the cultivated grapes would have passed the minimum requirement for soluble solids of 15 percent while in three out of five cases the mulched grapes would have met this requirement (Table 4). According to this criterion of soluble solids it is possible to produce grapes of acceptable quality at least a portion of the time under the mulch system of management. This point is further emphasized by the fact that juice of the 80 N mulched vines in 1957 contained higher soluble solids, 16.0 percent, than did juice from 40 N cultivated grapes in 1955, 15.5 percent soluble solids. This implies that differences between seasons can play just as important a part in determining soluble solids level as soil management system within a given season.

If one disregards soil management system per se and considers a broader base such as the nitrogen status of the vine it can be seen, as was the case with yield, that the soluble solids content of the juice was related to the level of nitrogen in the leaf petioles during early July (Figure 5 and 6). These figures show that in both raw and finished juices the soluble solids content declined as the nitrogen status of the plant as indicated by petiole content of nitrogen increased. In the case of the raw juice, which is important to the grower in meeting the minimum requirement for soluble solids, all cultivated treatments in 1955 and all cultivated and mulch treatments in 1957 produced juices with 15 percent or more soluble solids. If the yield-nitrogen relationship shown in Figure 4 is superimposed on the soluble solids-nitrogen relationship shown in Figure 5 it is apparent that acceptable production and soluble solids contents can be expected if the nitrogen content of the leaf petioles is within the range of 0.85 to 1.30 percent of the dry weight during a given season whereas yields and possibly soluble solids may be adversely effected if the nitrogen level of the petioles exceeds 1.30 percent. If this is a valid conclusion then it is also apparent that nitrogen treatment as such, which in the present study had no consistent effect on the soluble solids content of the fruit, and cultivation and mulch systems of soil management must be regarded very largely as regulators of the nitrogen status of the grape vine and must be employed by the grower in such a way as to achieve the desired level of production and quality.

A comparison of the data for soluble solids content of raw and finished grape juice (Table 4) shows that there was a decline in the soluble solids content of the juice following the processing and storage

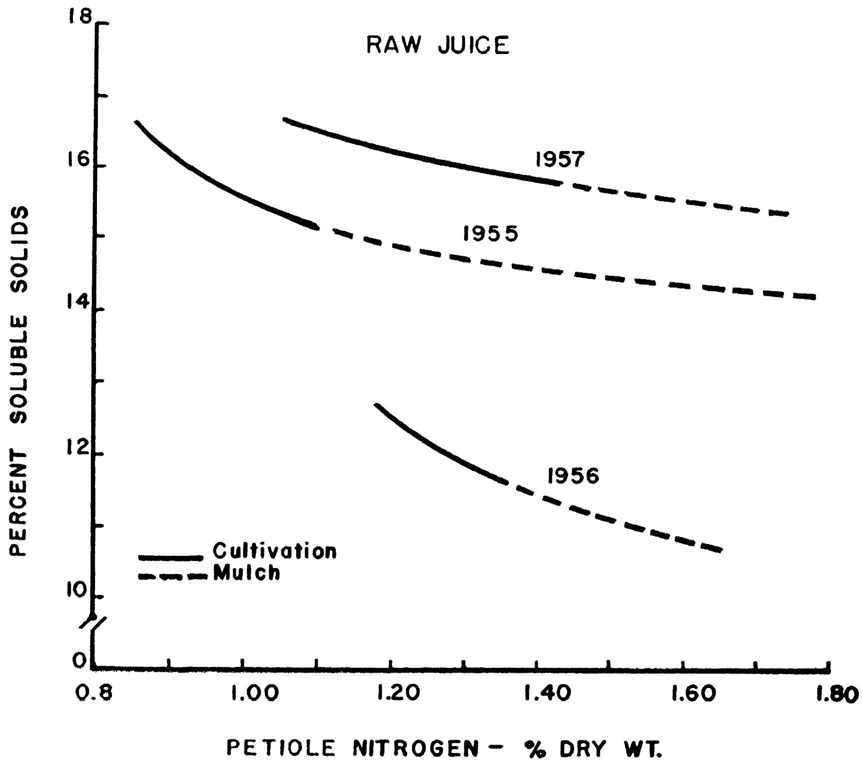

Fig. 5.—The relationship of the early July leaf petiole concentration of total nitrogen to the percent soluble solids in the raw juice of Concord grapes.

period. Two exceptions to this were the juice lots from the 40 N cultivated plots in 1955 and again in 1957. Several reasons are offered to account for this decrease during the processing and holding period. First, the raw juice samples were obtained by pressing the fruit without previous heating while the finished juice was made by heating the grapes to 145 degrees F. prior to pressing. The hot pressing technique may have given more complete removal of all of the fluids within the fruit rather than a large proportion of the high sugar juice found between the skin and pulp as would be obtained with cold pressing. Second, refractometer measurements of soluble solids in the raw juice would include all soluble solid materials such as tartrates, tannins, coloring matter,

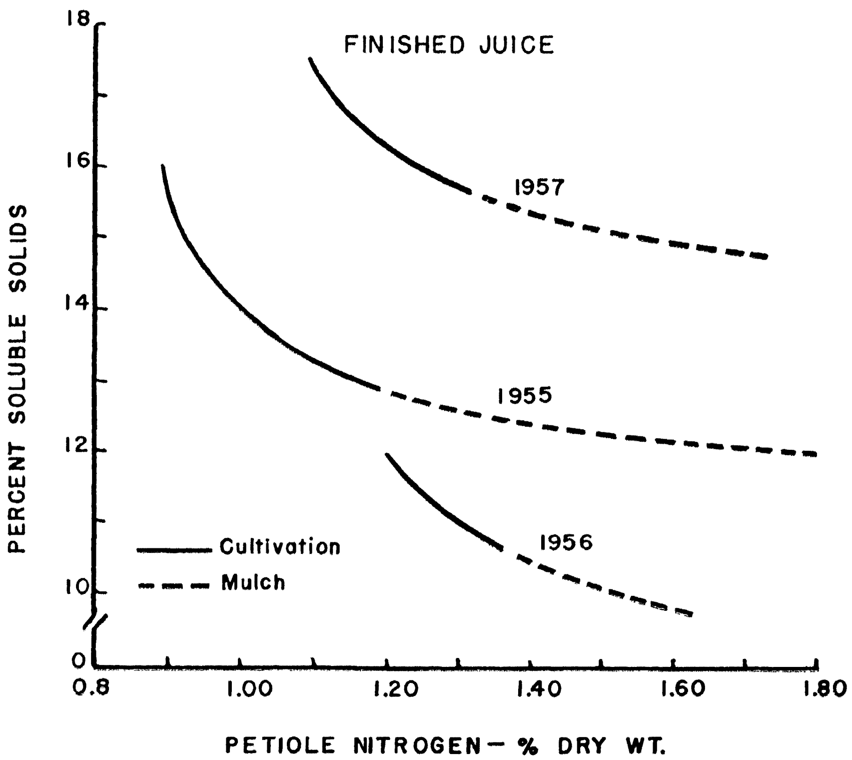

Fig. 6.—The relationship of the early July leaf petiole concentration of total nitrogen to the percent soluble solids in the finished juice of Concord grapes.

pectins, and acids. During the storage period many of these constituents precipitate out and thus the soluble solids content of the juice actually decreases. It has been shown by other workers that this takes place but the actual sugar content remains constant during the storage period (6). Because of the inclusion of constituents other than sugars in the refractometer determination of soluble solids, it has been suggested by Kertez (7) that a correction factor of 2 be deducted from the soluble solids content of Concord grape juice in order to closely approximate the true sugar content of the juice.

Total Acids.

The slightly higher acid content of raw grape juice from mulched vines (Table 4) is in agreement with previous reports which indicate that high vine vigor is associated with the production of a more acid fruit (4, 11, 12). No difference was found in the total acid content of finished juice samples from cultivated and mulched vines (Table 4). It was found, however, that the level of acid in the juices was higher in 1955 and 1957 after processing and storage than it had been in the raw juice. This may be largely due to the fact that hot pressing of the juice for processing results in the more complete removal of certain acidic materials such as tartartic, malic, and tanic acids and the relatively insoluble potassium bitartrate as has been suggested by Alwood (1) and by Hartman and Tolman (6). The fact that in 1956 the finished juice did not show an increased level of total acids over that of raw juice is believed to be a reflection of the immature condition of the grapes that season. Since the formation of insoluble potassium bitartrate from tartaric acid takes place close to maturation (2) it is believed that the 1956 grapes were pressed before this conversion took place and thus the cold pressing technique used on raw juice resulted in the rather complete extraction of total acids which were still present in soluble form.

The fact that the difference in total acid content of grape juice made from mulched and cultivated grape vines was small in comparison with changes in other constituents plus the fact that differential nitrogen treatment produced no consistent effect upon the total acid content of either the raw or finished juices suggests that this measurement by itself is not of sufficient importance to be helpful in evaluating the effect of these soil management practices and fertilizer treatments on the quality of the grape juice. This does not preclude the definite possibility that certain fractions of these acidic materials or the salts that result from them during the maturation process would be of interest and value in this regard.

Soluble Solids-Acids Ratio.

The ratio of soluble solids to acids has been proposed as a measure of grape maturity and quality (13). The supposition is that neither soluble solids nor acids alone give a true picture of edible quality, but rather it is the balance between these two constituents which determines the acceptability of the fruit. If this be true, it would seem logical that soluble solids-acid ratios which were very high would be unacceptable because the fruit and juice would be too sweet while very low ratios would typify juices which were too sour to be palatable. Furthermore, the same ratio could be obtained from lots of fruit which had low contents of both sugars and acids and from lots with very high contents of both sugars and acids. Soluble solids-acid ratios must be used with care for these reasons and are of most value when considered along with the individual solids and total acids data.

Because there was little difference in the total acid content of raw and finished juices from mulched and cultivated vines and between the different nitrogen treatments, the soluble solids-acid ratios presented in Table 4 show about the same trends as did soluble solids alone. Excluding the year 1956 when the fruit did not reach full maturity, it was found that the raw juice exhibited soluble solids acids ratios of 29 or above so long as the nitrogen level in leaf petioles in July did not exceed 1.30 percent. Finished juices from the same vines had soluble solids-acids ratios of 16 or higher when the July petiole nitrogen was 1.30 percent or less. As was the case with soluble solids, the level of nitrogen in the leaf petioles was more directly related to soluble solids-acid ratio than was either soil management system or differential nitrogen treatment. This reemphasizes the value of plant analysis for nitrogen in assaying the potential of the grape plant for high productivity of high quality fruit.

pH

Without exception, the pH of both raw and finished juice made from grapes from mulched vines was higher than that made from grapes from cultivated vines (Table 4). Thus, the hydrogen ion concentration of the juices from grapes grown under the mulch system of management was less even though the total acid content of these grapes was equal to or higher than that of those grown under cultivation. This may be accounted for in several ways. First, the proportions of the several organic acids making up the total acid content of grapes from cultivated vines may be such that there was a higher amount of dissociated acid in this juice than in the juice of grapes from mulched vines. Second, the buffering capacity of juice from mulched vines may be higher due to the presence of larger quantities of cations which in effect could reduce the active hydrogen ion concentration of these juices. The fact that the leaf petioles of mulched vines had a higher sum of cations than did cultivated vines lends indirect support to this possibility.

The pH of the finished juice from both cultivated and mulched vines increased from that existing in the raw juice. The change was greatest in the case of juice from mulched vines showing that during the processing and holding period more of the dissociated hydrogen ions had been removed. The significance of these changes in terms of their effect on the quality of the grape juice is not known and further study is required to help answer this question. The fact that differential nitrogen treatment had no consistent effect upon pH while soil management did produce a consistent, although small, difference in pH may be related to the fact that differential nitrogen treatments produced relatively small differences in nitrogen status as shown by petiole analyses for nitrogen while soil management treatments produced large differences in nitrogen status.

So far as the edible quality of the fruit or juice is concerned, total acids content would appear to have a far more pronounced influence than pH for it would be the total quantity of acids present rather than the fraction of those acids dissociated into hydrogen and basic ions which would be detected by taste.

Tannins.

A certain level of tannin is considered necessary to give grape juice body and character but if the tannin level becomes too high a bitter or astringent flavor is imparted to the juice. Caldwell (5) stated that the amount of astringent material present in grape juice was as important as the sugar acid ratio in determining quality. According to the literature, tannin content of Concord grapes varies from season to season (5). The average tannin content of Concord juice following a four month storage period was reported by Hartman and Tolman (6) to be 180 milligrams per 100 grams with a range of from 130 to 220 milligrams per 100 grams. It has further been reported (5) that as the acid content of grapes increases so does their tannin content while tannins and sugar content vary inversely.

The contention that tannins vary considerably from season to season is supported by the data in Table 4 for both raw and finished juices. The range in tannin content of finished juice was found to be from 116 to 292 milligrams per 100 grams of juice which extends the range reported by other investigators (6). Only in the case of the 1957 crop did the tannin content of the finished juice exceed 202 milligrams per 100 grams of juice and comments made by many of the members of the taste panel disclosed that the juice that year had a bitter or astringent taste which lowered its quality to such a degree that it was unacceptable to some.

The tannin content of all lots of juices were lower following processing and storage than had been the case in the raw juices. Juice made from grapes grown under mulch had consistently lower tannin levels than juice from grapes under cultivation. According to the preferences expressed by taste panel members, tannin content ranging from 150 to 232 milligrams per 100 grams gave the most acceptable juices irrespective of whether cultivation or mulch was the soil management system used. At the same time tannin content of the juice in excess of 257 milligrams per 100 grams rendered the juice unacceptable to members of the taste panel. If the tannin values presented in Table 4 are compared with leaf petiole nitrogen values presented in Table 3, it will be found that as petiole nitrogen increased tannin content of the finished juice decreased. This relationship is such that leaf petiole nitrogen levels in excess of 1.30 percent were associated with tannin levels in the finished juice of less than 150 milligrams per 100 grams, the tannin level below which juice samples were found unacceptable by the taste panel.

Organoleptic Evaluation.

The preference expressed by members of the taste panel for juice made from grapes produced on vines under cultivation in 1955 and 1956 and for juice from grapes from mulched vines in 1957 is not fully explained on the basis of soluble solids, acids, soluble-acid ratio, or pH. In all three of these years the soluble solids content and the soluble solids-acid ratio was higher, the acid content was essentially the same, and the pH was lower in the case of juice made from grapes grown under cultivation. In other words, although there were differences in magnitude of these factors between the three years of the study, the relationship of one with another remained the same. The switch in preference from juice of the cultivated plots to that of mulched plots in 1957 can be explained, however, on the basis of the tannin content for as was indicated in the previous section the tannin content of mulched vine grape juice was too low in 1955 and 1956 and that of cultivated vine juices was too high in 1957.

The importance of the soluble solids-acid ratio as a measure of juice quality is further emphasized by the fact that in 1955 and 1956 when the soluble solids-acids ratios were adjusted by the addition of sugar it was not possible for taste panelists to discern between the juices made from grapes of cultivated and mulched vines. In 1957, however, the high tannin content of the juice from grapes grown under cultivation proved to be such an important factor in determining quality that the equalization of the soluble solids-acid did not prevent the taste panelists from prefering the juice of grapes from mulched plots.

In summarizing the results of the organoleptic evaluation of these juice samples it is concluded that soluble solids-acids ratios proved to be a highly satisfactory means of predicting relative quality so far as the taste panelist was concerned, provided that the tannin content of the juice was within the range of 150 to 230 milligrams per 100 grams of juice.

SUMMARY AND CONCLUSIONS

1. Detailed production records and leaf petioles analyses were obtained on Concord grape vines grown under mulch and cultivation systems of soil management and with different rates of nitrogen fertilizer application from 1955 through 1957. Concurrently fruit samples from the six differential treatments were pressed into raw juice and manufactured into finished grape juice and quality evaluations made on these juices.

2. Average yield per vine was highest under the mulch system of management in 1955, equal under mulch and cultivation in 1956, and lowest under mulch in 1957.

3. The increased yields obtained under mulch in 1955 as well as in earlier years with the mulch system appeared to be closely associated with rainfall during the five months of the growing season from May through September.

4. When the May through September rainfall was 17.26 inches or less, the mulched vines outyielded cultivated vines. When the rainfall for this period exceeded 19.89 inches the cultivated vines outyielded the mulched vines.

5. Levels of petiole nitrogen during early July in excess of 1.25 to 1.30 percent of the dry weight were associated with reduced yields. In 1957, leaf petiole potassium values ranging from 4.99 to 6.05 percent under the mulch system of management were also associated with reduced yields.

6. Mulched vines produced more vegetative growth as measured by weight of one-year old prunings than did comparable cultivated vines.

7. Mulched vines produced leaf petioles with higher concentrations of nitrogen, phosphorus and potassium and lower concentrations of calcium and magnesium than did comparable cultivated vines.

8. Cultivated vines produced larger clusters and more fruit per bud left during pruning than did mulched vines.

9. The soluble solids content of both raw and finished juice from grapes from cultivated vines was consistently higher than that of juice from grapes of mulched vines. This was believed to be due to the high nitrogen status of the mulched vines as evidenced by weight of wood produced and leaf petiole analysis for nitrogen. The relationship between leaf petiole nitrogen and soluble solids content of both raw and finished juices suggested that higher levels of soluble solids can be anticipated if the leaf petiole nitrogen is maintained in the range of 0.85 to 1.30 percent rather than above this range.

10. The levels of nitrogen fertilization employed in this study did not have a large or consistent effect on the soluble solids content of either raw or finished juices. This is believed to be due to the relatively small differences in nitrogen status brought about by differential nitrogen fertilization in comparison with the large differences resulting between the two soil management systems.

11. The finished grape juice had a lower soluble solids content than the raw juice. This difference was more pronounced in the case of juice made from fruit of the mulched vines.

12. In the case of raw juice, the total acid content was slightly higher in the case of mulched than of cultivated vines. For finished juices the acid content was essentially the same under both systems of soil management.

13. With fully matured grapes as in 1955, the total acid content of the finished juice was always higher than that of raw juice. This may have been due to differences in the extraction of acids by cold pressing for the preparation of raw juice and hot pressing for the preparation of finished juice.

14. The soluble solids-acids ratio of the finished juice made from grapes of cultivated vines was always higher than that from mulched vines. In the same manner that soluble solids content was related to leaf petiole nitrogen, the highest soluble solids-acids ratios in any given year were found when leaf petiole nitrogen was in the range of 0.85 to 1.30 percent of the dry weight. Thus, the primary effect of mulch appears to be through its influence upon nitrogen status.

15. The raw and finished juice of grapes from mulched vines had higher pH values than did juice from grapes of cultivated vines. This may have been due to a higher buffer capacity of the juice from mulched vines which resulted from a greater accumulation of cations in vines maintained under mulch.

16. Under each of the soil management systems, the members of the taste panel were unable to distinguish between juice samples representing the different nitrogen treatments.

17. Members of the taste panel did distinguish between juice samples representing the cultivation and mulch soil management systems. In 1955 and 1956 the preference was for juice of grapes from cultivated vines. In 1957 the preference was for juice representing the mulched vines which received the 0 and 40 N treatments.

18. The change in preference from juice representing cultivated to that of mulched vines was related to tannin content. Juice

samples which contained from 150 to 232 milligrams of tannin per 100 grams of juice were preferred to those containing more or less tannin.

19. The value of the soluble solids-acids ratio as a means of evaluating the relative quality of different lots of juice was emphasized by the fact that when 1955 and 1956 juice samples representing the two soil management systems had the soluble solids-acid ratio equalized by the addition of sugar it was impossible for members of the taste panel to discern between them.

20. The importance of tannin content in determining juice quality was emphasized by the fact that in 1957, the juice from grapes of mulched vines was preferred, apparently because of its lower tannin content even though it possessed a lower soluble-solids-acids ratio than that of cultivated vines.

21. In consideration of all of the indices of production and of quality of the fresh and processed product evaluated in the present study, it would appear that nitrogen is of primary importance in attaining the desired result. These results indicate that a range of from 0.85 to 1.30 percent nitrogen in the leaf petioles of Concord grapes during early July represents a level of nitrogen nutrition which permits a desirable balance between vegetative vigor and the productivity of high quality fruit. Within this range, nitrogen content of the leaf petioles and yield were found to be positively correlated. Within this range the soluble solids content of the raw and finished juices and their soluble solids-acids ratios were highest although it should be pointed out that the nearer the upper limit of the proposed nitrogen range was approached the more likely the possibility of a reduced level of soluble solids. Finally, wihin this nitrogen range the tannin content of finished juices was found to coincide within those limits which impart desirable body and character to juice as indicated by the preference of members of the taste panel.

REFERENCES

1. Alwood, W. B. 1911. Ecological Studies. The chemical composition of American grapes grown in Ohio, New York, and Virginia. U. S. Dept. of Agr. Bur. Chem. Bul. 145, 35pp.

2. ————. 1914. Crystallization of cream of tartar in the fruit of grapes. J. Agr. Res. 1: 513-514.

3. Association of Official Agricultural Chemists. Official and Tentative Methods of Analysis. 6th Ed., Washington, D. C. 1945.

4. Beattie, James M. 1955. Mulch as a management system for grapes. Ohio Agr. Exp. Sta. Res. Cir. 28.

5. Caldwell, J. S. 1925. Some effects of seasonal conditions upon the chemical composition of American grape juices. J. Agr. Res. 30: 1133-1176.

6. Hartman, B. G. and L. M. Tolman. 1918. Concord grape juice: manufacture and chemical composition. U. S. Dept. Agr. Bul. 656. 27pp.

7. Kertesz, Z. I. 1944. The chemical composition of maturing New York state grapes. N. Y. Agr. Exp. Sta. Tech. Bul. 274. 13pp.

8. Peech, Michael. 1945. Determination of exchangeable cations and exchange capacity of soils. Rapid micro-methods utilizing centrifuge and spectrophotometer. Soil Sci. 59: 25-38.

9. Roessler, E. B., J. Warren, and J. F. Guymon. 1948. Significance in triangular taste tests. Food Res. 13: No. 6. 503-505.

10. Rosenblatt, M. and J. V. Peluso. 1941. Determination of tannins by photocolorimeter. J. Assoc. Off. Agr. Chem. 24: 170-181.

11. Upshall, W. H. and J. R. Van Haarlem. 1934. Yield and quality of fruit from strongly vegetative Concord grape vines. Sci. Agr. 14: 438-440.

12. Williams, W. O. 1946. California vineyard fertilizer experimentation. Proc. Amer. Soc. Hort. Sci. 48: 270-278.

13. Winkler, A. J. 1932. Maturity tests for table grapes. Calif. Agr Exp. Sta. Bul. 529.